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University-Firm Interaction in South Africa: Extent and Intensity[i]

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Introduction

The significant contribution that the university can make to social and economic development in Africa is now well-established. Whereas the higher education sector in general had previously been neglected by international development agencies, African countries are now urged to restore the role of higher education as a public good and transform universities to institutions of relevance that are responsive to national priorities. Exactly what the priorities of the 'public good' in Africa should be has been the subject of much debate.

Increasing globalization, the rise in importance of knowledge in economic growth, and rapid developments in information and communication technology (ICT) have brought about significant changes to the university environment necessitating a re-examination of university priorities (Jibril 2004; World Bank 2002). Traditionally, the main roles of the university are to develop appropriately skilled human resources for the labour market and to act as the producers and custodians of knowledge (Kotecha 2004). It is argued by some (e.g. Lundvall 2007a, 2007b) that teaching is still the most important function of the university, but that the manner of teaching should change to that of encouraging learning in developing appropriately skilled individuals for adapting, using and improving technologies adopted from elsewhere and innovating at the frontier. In other words, the most important function of universities in the knowledge economy is to contribute to the development of the absorptive capacity necessary for building technological capabilities.

Although there is general consensus with regard to the educational function of the university, the modes by which the university fulfils its function as a knowledge producer is debatable. Some argue that it is imperative that universities align their research activities with priorities and needs of industry – a second component of the technological capability building process (Dutrénit 2004) - as a way of fulfilling their potential as significant contributors to economic growth and development. Others argue against the commercialization of university research and advocate the preservation of the university as independent from market forces, keeping the image of the 'incorruptible' generators and custodians of knowledge. Although some tend to agree with either extreme, the debate is not simply a matter of either/or.

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As knowledge producers, universities can contribute to economic development in various ways: commercializing research by patenting or licensing research; creating spin-off companies and/or incubators; and in collaborating with industry which includes research consultancy, collaborative research projects and capacity development initiatives. University collaboration with industry has been the focus of much research, including research employing the national system of innovation framework, providing evidence that such collaborations yield significant returns with regard to firms' technological capabilities and innovation at the frontier. This evidence has been taken up by international funding agencies and policy-makers, including African governments, bringing about policies that encourage university-industry linkages (UILs). The concern that arises is that the extant literature on UILs is dominated by research on UILs in advanced economies. Although there is a growing body of literature on UILs in the developing country context, this area is still under-researched and research on UILs in the context of sub-Saharan Africa is particularly lacking. A concern raised by researchers on the role of the university in the national system of innovation is that African governments, perhaps motivated by international development agencies, have begun to introduce grand science and technology and innovation policies that may not be appropriate for the African context. For instance, the historical trajectories of African countries (including political transformation and economic reform that influence technological and sectoral priority for example) that shape national systems of innovation differ from that of advanced countries. Policies that are not based on contextual understanding may result in strategies that are never fully implemented and may result in wasted resources and may also be met by resistance from agencies in the country's national system of innovation.

Thus it is clear that an understanding of the context and the mechanisms at play in the specific country's national system of innovation is imperative for developing adequate strategies and policies. This brings about the need for systematic empirical research focusing on determining what exists.

As a first step in broadening the research base and deepening the understanding of UILs in South Africa, the present paper presents empirical research analysing the role of universities as collaborators with industry in research and development in South Africa, sub-Saharan Africa's most advanced economy. In South Africa there is a small emerging body of context-specific and systematic empirical research on UILs. The existing empirical research has however focused more on UILs from the perspective of the university, including an in-depth analysis of the ways in which the universities' historical backgrounds, infrastructure and institutional structures facilitate and constrain UILs. The products of this research are a conceptual framework for understanding UILs from the *perspective of the university* and a relatively good understanding of the forms and nature of UILs from the *perspective of the university*. As various authors emphasise (e.g. Kruss and Lorentzen 2007; Malerba and Nelson nd), an understanding from the other side of the coin, that is, the *perspective of the firm*, is necessary. There is however a dearth of research in this area.

The paper attempts to address this gap and explores South African firms' propensity to collaborate on R&D activities and the importance of the university as a collaborative partner. The paper furthers existing research on UILs in South Africa by attempting to profile, on a national scale, R&D-performing firms that tend to collaborate with universities in comparison with firms which do not collaborate at all, and firms that collaborate with agencies in the national system of innovation other than universities. In order to achieve this aim, the paper draws on data from South Africa's National Innovation Survey 2005 and its National Survey on Research and Experimental Development 2005/06. Although these surveys were not designed to measure UILs specifically, they include questions on firm collaboration with other agencies in the national system of innovation, including universities. The surveys thus provide useful and important data on the number and nature of South African firms with a propensity to collaborate on innovation and R&D activities, and the importance of the university as a collaborative partner.

The present study forms part of a broader empirical study that explores the developmental role of the university in South Africa with particular focus on the state of university-industry interactions. The broader study investigates the state of UILs in three sub-Saharan African countries at different levels of economic development - South Africa, Nigeria and Uganda – and aims to contribute to the clarification of the potential of UILs for sub-Saharan Africa's development in the context of increasingly knowledge-based global competition.

Section 1 draws on the existing body of literature provide a description of the forms that UILs take in the South African context. The section reports the main findings of UILs discussed in the extant literature, including findings of the South African national Innovation and R&D surveys. It considers the 'lessons learnt' from the literature in building on research in the area. Section 2 describes the methodology employed in the analysis. Section 3 draws on the Innovation survey report and the R&D survey data in describing the scale of UILs from the perspective of the firm. It provides an analysis of data extracted from the South African National Survey of Research and Experimental Development (2005/06) in profiling the R&D-performing firms that tend to collaborate with other agencies in the national system of innovation, and universities in particular, in comparison with those firms that do not report having had collaborative partners. Section 5 concludes the paper and provides suggestions for future research.

1. University-industry linkages in the South African Context

Policy environment

The South African government, after the political transition in 1994, introduced clear policy - starting with the White Paper on Science and Technology (1996) - that encourages collaboration between universities and other agencies in the national system of innovation, particularly industry. Policy calls for universities to become more responsive to national priorities and contribute to social and economic development. In addition to their core functions of knowledge generation and dissemination, universities

are expected to engage in research activities that are more "'relevant', applied and strategic, in partnership with industry or other science council partners" (Kruss 2007: 1).

Science and Technology and Innovation Policy in South Africa has evolved over time with strategies becoming more focused and based on the growing body of contextually-based research (see Kaplan 2008 for a more detailed description). For example, DST's Ten-Year Innovation Plan (2008-2018) provides a strategy for the promotion of innovation for socio-economic development by "improving access to finance, creating an innovation-friendly regulatory environment and strengthening the NSI" (p. v). The plan highlights five 'challenges': biotechnology, space science and technology, energy, climate change and human and social dynamics. One strategy for providing financial support for strengthening the NIS in South Africa is the incentivisation of UILs through initiatives such as the Technology and Human Resources for Industry Programme (THRIP) and the Innovation Fund. THRIP was launched in 1991 and is managed by the National Research Fund (NRF) on behalf of the Department of Trade and Industry (DTI). Its main aim is to promote higher education and industry collaboration in the development of human resources appropriately skilled for understanding, adapting and using new knowledge and technologies, and creating at the frontier. The Innovation Fund was initiated a few years later in 1999 and is managed by the NRF on behalf of the Department of Science and Technology (DST). It aims to "promote technological innovation and transdisciplinary collaboration within the research community by encouraging and supporting longer-term, large-scale, collaborative innovation projects in the higher education sector, government science councils, civil society and the private sector" (Letseka 2005: p.162). Letseka (2005) reports the results of an HSRC audit (focusing on the period 1999 to 2002) of THRIP and the Innovation Fund funding activities. He reports that the two funds incentivised 423 industry-higher education-SETI partnerships amounting to R869 million with THRIP accounting for the majority of the share of partnerships (87%) and the funds (64%). Seventy-five percent of the THRIP budget went to universities whereas in 2002 and 2003 only 28% of the Innovation Fund budget went to universities. The large number of industry-higher education-SETI partnerships funded and the high value of funds allocated to these partnerships are an indication of the South African government's commitment to the promotion of UILs.

South Africa thus has a favourable policy environment for the development of UILs. It has a regulatory framework, strategies and funding mechanisms that incentivises the development of UILs and support the operation of UILs. It is important to note that these policies and strategies have evolved over time to become more focused, and there have been problems in implementation, with policy being implemented unevenly across institutions.

Existing empirical research: forms of UILs in South Africa

A small body of literature on the existence and nature of UILs in South Africa has emerged in the past few years (Blankley, 2007; Cele 2005, Cooper 2005; Kahn and Blankley 2005; Kruss 2005, 2006, 2008; Kruss and Lorentzen 2007; Letseka 2005; Oerlemans and Pretorius 2006; Abrahams and Melody 2005; van Zyl, Amadi-Echendu and Bothma 2007). Kruss (2007), in a meta-study on research on UILs in South Africa, provides a useful description of the main findings of the existing body of literature and reports the dominant forms of UILs in the South African context:

- The traditional forms of UIL, including firm donation of funds (e.g. for equipment, a chair or student bursaries) with few conditions attached, sponsorship of research centers or student sponsorship as forms of corporate social responsibility programmes that are mainly financial rather than research collaborative, and UILs aimed at capacity development and redressing past racial inequalities.
- New dominant forms of UILs for research utilization and technology transfer, including consultancies with the researcher acting as an advisor on specific projects for addressing the more short-term objectives of firms, and contracts. Contracts between universities and industry are often initiated to secure funding for a research centre, academic research activities and/or attracting postgraduate students. Contracts often address more medium term firm objectives and may include "a degree of knowledge collaboration" and often require the university to develop a particular product or deliverables. According to Kruss (2005), contract UILs are the most dominant forms of UILs nationally.

The dominant forms of UILs in South Africa are often primarily financial transactions as opposed to knowledge-intensive collaborations that are often aimed at addressing the short- or medium-term knowledge and technology needs of the firm, and often initiated by and benefit individual academics on the university's side. UILs are also often initiated in fulfilling capacity development needs and in so doing redressing past inequalities. The dominant forms of UILs also often serve to provide much-needed financial support to the university in their academic endeavours, and public-private partnerships are a growing necessity considering diminishing state funding with the introduction of new funding models. Kruss (2007) however raises the concern that the dominant forms of UILs that aim to mainly address the short-term needs of firms may restrict the teaching and knowledge generation imperatives of the university if they grow in scale and carry on for long periods. They suggest that ideally, universities should aim to collaborate with firms on more knowledge-intensive activities for the development of innovative capacity, that is, UILs that are more mutually beneficial.

Kruss and Lorentzen (2007: 17) refer to such UILs as "innovation forms of UIL" which "are mutually beneficial knowledge intensive relationships between academics, departments or units and industry that involve collaboration in knowledge generation, diffusion and/or application that will ultimately contribute to innovation". Research on UILs also shows that knowledge-intensive UILs exist on a very small scale in South Africa, but are growing in number. Innovation forms of UILs in South Africa take the form of complex networks (research and technology transfer), UILs incentivized by government funds to encourage technology transfer and the development of innovative

capacity (via the Innovation Fund and THRIP), and commercialization UILs referring to UILs that are entrepreneurial and aimed at commercializing knowledge and technology (creating spin-offs, patenting and licensing UIL outputs). Innovation UILs often aim to address the long-term needs of industry and contribute to innovation and the development of firms' technological capabilities.

UILs in South Africa also show differing degrees of concentration in the different technology fields or sectors (Kruss 2006; Kruss and Lorentzen 2007). The existing body of literature has focused on specific sectors: biotechnology (Klerck 2005), ICT (Kruss and Lorentzen 2007; Paterson 2005), new materials development (Godfrey 2005), and Kruss and Lorentzen (2007) focused on the wine and boatmaking industries. It is clear from the literature that the existence and nature of UILs in South Africa, and thus their contributions to innovation activities, differ according to type of technology and sector more generally. The importance of sectoral differences in the required level of technological capability, and the importance of a knowledge base and thus collaboration with knowledge producers (such as universities) has been highlighted in the local and international literature (see for example Malerba and Nelson nd). The present study takes this into account and analyses sectoral differences in collaboration generally, and collaboration with universities in particular.

The next section describes the methodology employed in exploring the existence and importance of UILs for the innovation activities of innovative firms, and for R&D-performing firms.

3. Methodology: exploring UILs from the firms' perspective

The aim of the present paper is to explore the ways in which UILs differ across sectors in South Africa, sub-Saharan Africa's most advanced economy. Important research questions that arise in exploring UILs from the firm perspective, which will be addressed by the broader study are:

- What is the level of the firms' interaction with universities?
- What are the types of firms (size, industrial sector, etc) engaged in collaborative R&D?
- What are the main modes and channels of communication?
- What are the benefits of and obstacles to collaboration?

The present paper attempts to address mainly the first two questions. The paper is able to address the third question to an extent but this is limited by the lack of adequate data. The paper describes South African firms' propensity to seek partnerships with higher education institutions in their innovative and R&D activities, and in this way describes the importance of the university as a collaborative partner for innovation. The second question is addressed by profiling the firms in terms of their collaborative propensities. The objective is to identify the types of firms that tend to collaborate with universities by profiling, on a national scale, innovative and R&D-performing firms that tend to collaborate with universities in comparison with firms which do not collaborate at all, and firms that collaborate with agencies in the national system of innovation other than

universities (including science councils, government research institutions, firms and not-for-profit organizations). The profile of the firm includes a description of:

- firm characteristics – firm size (number of employees grouped according to the OECD's classification system) and primary sector (with manufacturing classified according to the OECD's classification system).
- R&D activity – R&D expenditure, type of research activities (basic, applied and experimental) and R&D personnel.
- collaborative propensity – a simple indication from the firms as to whether they interact with others in the national systems of innovation and if so, with whom they have sought co-operation on their innovative and/or R&D activities. Possible partners include science councils, government research institutions, other members of their firms, other firms and not-for-profit organizations.

The characteristics that make up the firm profile, including the 'firm characteristics' and 'R&D activity', have been identified in the literature as significant factors influencing the propensity of firms to collaborate and their choice of collaborative partners (see for example Busom and Fernández-Ribas 2007).

Data sources

Two large-scale sources of data on firm collaboration available in South Africa are the National Innovation Survey 2005 and the National Research and Experimental Development Survey 2005/06. The Innovation Survey is based on the Oslo Manual and the R&D survey on the Frascati Manual, making these surveys comparable internationally. The R&D and Innovation surveys differ in that the Innovation Survey targets a stratified random sample of all firms included in the national business directory and distinguishes between innovative and non-innovative firms; whereas the R&D Survey targets known R&D-performing firms (public and private) only, using a purposive sampling strategy. The R&D Survey thus forms an elevated sub-set of the 'innovation landscape'.

Although the surveys have the advantage of being large scale national surveys that are internationally comparable, they are not designed to measure collaboration specifically and in-detail. The surveys are limited in informing our understanding of the nature of UILs in South Africa, but nonetheless provide useful information on the scale of UILs in the country and some of the channels of information flows important for South African firms' innovative activities. The inclusion of questions on collaboration in the surveys can be taken as an indication of the significance of the role of collaboration in R&D and innovation activities. Apart from the aggregated descriptive statistics reported in the annual survey reports (CeSTII 2007, 2008), these surveys are usually not used to analyse collaboration specifically. The surveys are thus untapped rich sources of data on the scale and nature of firm collaboration in South Africa.

An Innovation Survey 2005 report published in July 2008 (CeSTII 2008) will be used in determining the scale and importance of universities as co-operative partners and sources of information for firms' innovative activities nationally. The R&D survey covers a sub-set of innovative firms, R&D-performing firms, and will be used in determining the scale and importance of universities as collaborative partners in the firms' R&D activities.

The 2004/5 and 2005/06 R&D surveys included a question measuring firm collaboration. Respondents in the business sector were asked to indicate whether they collaborated with higher education institutions, science councils, government research institutions, members of their own or affiliated company, other firms or not-for-profit organisations.

The 2004/05 dataset that included the question on collaboration did not include an option for firms to indicate that they do not collaborate. Non-collaborators would thus appear as missing-entries on this question and thus a comparative group of non-collaborators could not be accurately identified. This dataset could thus be employed for the purposes of this paper.

The 2005/06 dataset included this question. It was decided that this dataset would be adequate for profiling the collaborative in comparison to the non-collaborative firms.
The following section draws on the published results of the South African National Innovation Survey (2005) and the National Survey of Research and Experimental Development 2005/6.

Section 5. UILs in South Africa: scale and nature of collaborative firms

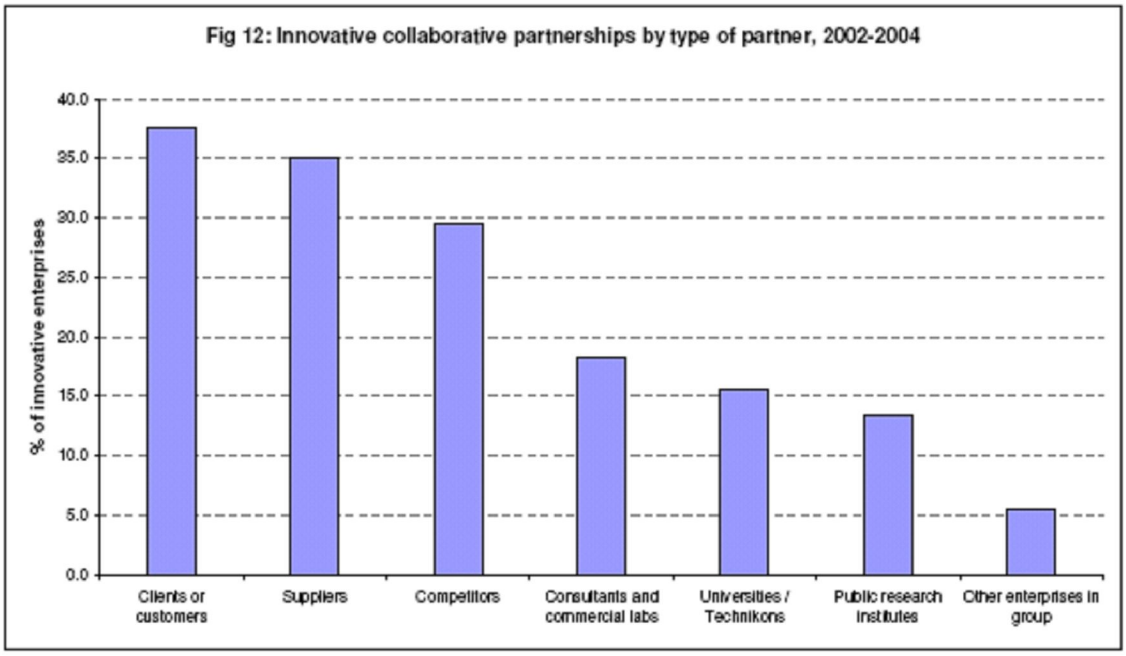
Scale of UILs in South Africa

Innovation Survey 2005

The South African Innovation Survey measures firms' innovation-related activities for the period 2002 to 2004. The survey obtained 979 responses from a random stratified sample of 2 627 companies. Fifteen percent of the non-responses were surveyed again and an 89% response rate was obtained from this cohort. This data informed weights for the extrapolation of strata to generate national statistics.

In the three-year period 2002 to 2004, 51.7% of South African enterprises were engaged in innovation activities (CeSTII 2008). About a sixth of the innovative firms (15.5%), which refers to about 9% of all firms (including non-innovative firms), indicated that they had co-operated with higher education institutions (HEIs) on their innovative activities during the three-year period (see Figure 1 below).

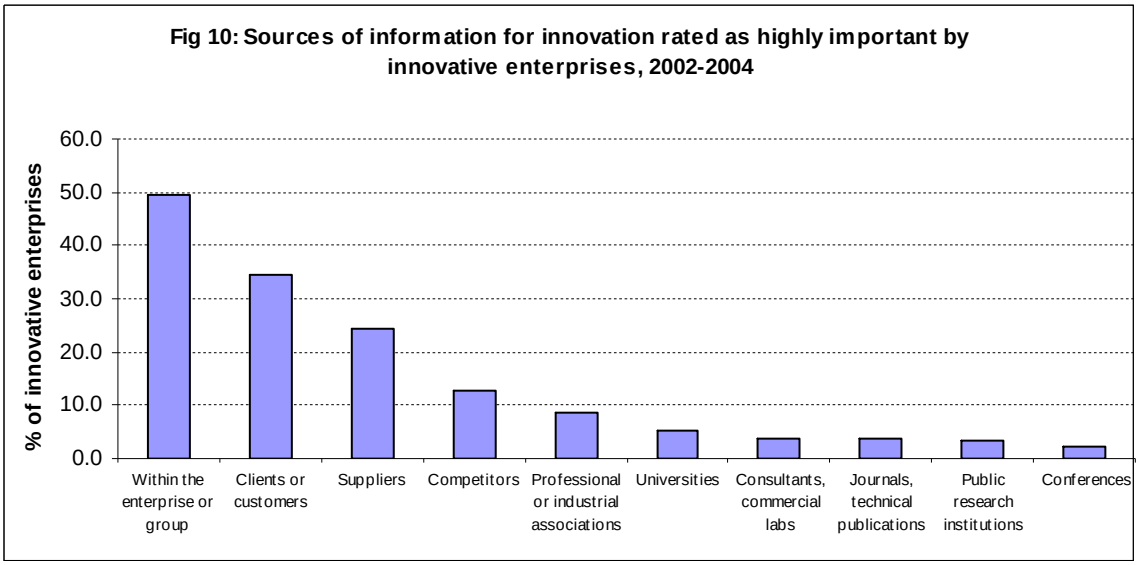
Figure 1. Innovative firms' collaborative partnerships by type, 2002-2004



Source: Extracted from the South African National Innovation Survey 2005 report (CeSTII 2008).

Innovative firms' co-operation with other agencies generally displayed a trend similar to that of many European firms with the larger proportion of co-operation being with agencies more closely related to the firms' market-related interactions, including clients or customers (37.5%), suppliers (35.0%) and competitors (29.4%). The average proportion of firms co-operating on innovative activities was however considerably larger (about 40%) than the EU-27 average (26%) (CeSTII 2008). Universities and technikons are also more important co-operative partners in innovation activities for the South African firms (15.5%) than the EU firms (between 6% and 9%) (European Communities 2007).

Figure 2. Sources of innovation for innovation, 2002-2004

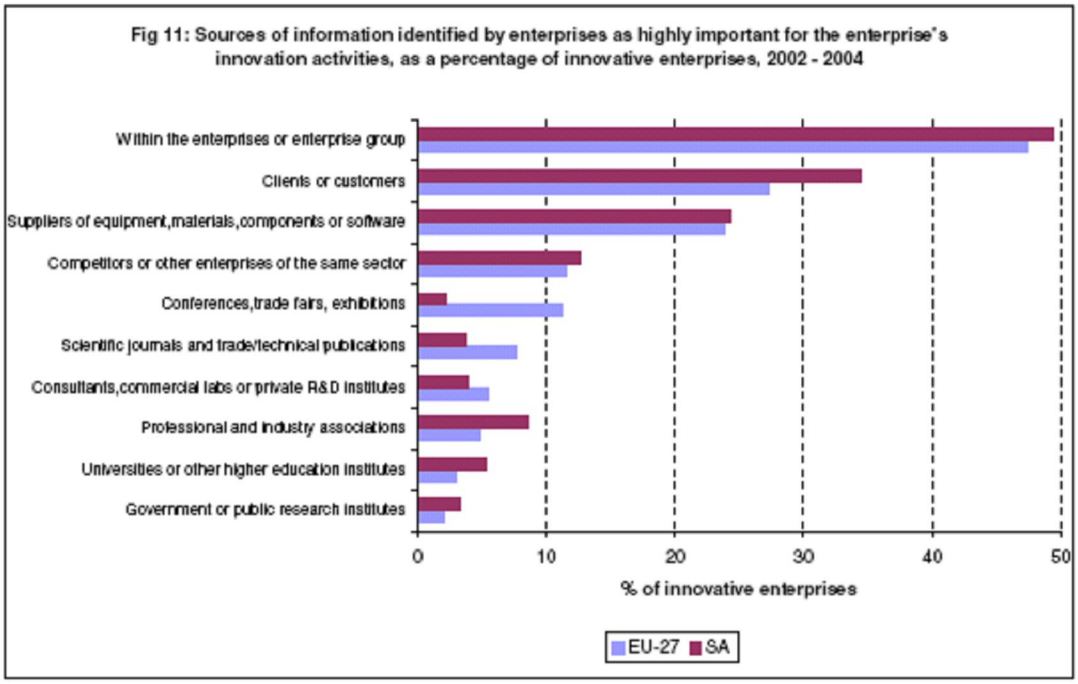


Source: Extracted from the South African National Innovation Survey 2005 report (CeSTII 2008).

The trend of the sources of information for innovative activities is similar to that of many European countries. Co-operation with market-related sources, including the enterprise group (49.3%), clients or customers (34.5%), suppliers (24.3%) and competitors (12.6%), were the important sources of information for the innovative activities of a larger proportion of firms.

A relatively small number of innovative firms in South Africa and an even smaller number of all South African firms (innovative and non-innovative), regard universities/technikons (5.2%) and government and public research institutes (3.4%) as important sources of information for their innovative activities (see Figure 2). These figures compare favourably with the European Union average (EU-27) of 3.6% and 2.7% respectively (European Community 2007). This prompts questions about an appropriate figure for developing nations. Other sources that universities may be directly involved in are conferences, trade fairs and exhibitions, and scientific journals. These sources were regarded as important sources for very few South African firms with 2.2% and 3.8% of firms identifying conferences. and scientific journals (respectively) as important for their innovative activities, which is considerably less than the average for the EU-27 (see Figure 3).

Figure 3. Sources of information for innovation as a percentage of innovative firms in comparison with the EU-27, 2002-2004



Source: Data for EU-27 are from European Communities (2007c); South African data are from Appendix Table 11A.

Source: Extracted from the South African National Innovation Survey 2005 report (CeSTII 2008).

To sum up, universities/technikons were important co-operative partners for about 15% of innovative firms, and a mere five percent of innovative firms identified universities/technikons as important sources of information for their innovative activities. This suggests that the knowledge produced by universities is under-utilised by firms as a knowledge base for innovative activities. The question of the nature, and the knowledge-intensity of the firms' co-operative activities with universities more specifically, is however left unanswered. This question can be addressed, to some extent, by the national data on R&D-performing firms, which can be referred to as an elevated sub-set of the 'innovation landscape'.

R&D Survey 2005/06

The R&D survey 2005/06 obtained responses from 607 firms of which 327 responded to the question on firm collaboration. The sample was dominated by small and medium firms (45%) and large firms (43.1%) (see Table 2 on page 14). The dominance of larger firms is contradictory to the distribution of firms in South Africa where nearly half of the firms are micro firms and large firms account for about one percent (OECD 2007). This is because the R&D survey first seeks to survey large R&D-performing firms, which also tend to be larger employers. More than a third (39.1%) of the firms in the sample were in the financial and business services sector and 44% were manufacturing firms, of which, 29.9% were medium-high technology and 25% were high technology firms. This distribution is in-line with the structure of the South African economy where manufacturing and financial and business services account for the largest shares of GDP,

with the latter being one of the fastest growing sectors in South Africa (OECD 2007). The firms in the sample showed high mean and median R&D expenditures and tended to place more emphasis on experimental research. The total R&D expenditure for the sample was some R6 billion, which represents 72.9% of the total in-house R&D expenditure for the business sector recorded in 2005/06 (a reported total of about R8.2 billion) (CeSTII 2007).

In profiling the firms' collaboration propensities, the characteristics of the firms that tend to collaborate were determined and compared to the characteristics of firms that indicated that they did not collaborate on their R&D activities in the 2005/06 financial year.

Collaboration propensities: collaboration versus non-collaboration

In 2004/05 167 of the R&D-performing firms indicated collaboration on R&D activities. In the following year (2005/06), the survey received a greater response from the business sector, and the number of firms reporting collaborative R&D partners was considerably higher (218), with 109 firms indicating that they did not collaborate on R&D activities. As shown in Table 1, the patterns of collaboration partners are similar for the two years. Local higher educations institutions (HEIs) were the most sought after collaboration partners. The importance of higher education for this sub-set of firms makes sense considering that R&D-performing firms generally engage in more knowledge-intense activities. Although the firms indicated some collaboration with HEIs situated outside of the country, they tended to prefer local institutions, which implies some success on the part of local HEIs in making themselves relevant.

Table 1. Number of R&D collaborations, 2004/05 and 2005/06

	2005/06 Count		2004/05 Count	
Partner	S A	Foreign	S A	Foreign
Higher education institutions	120	31	100	23
Science councils (e.g. CSIR, Mintek, MRC, ARC etc)	82	16	66	9
Government research institutes	43	14	22	9
Members of own company/ Affiliated companies	83	54	65	40
Other companies (including specialist consultants)	99	62	81	47
Not-for-profit organisations	15	4	5	3
TOTAL	442	181	339	131
NO COLLABORATION	111	79	no data*	no data*
* Question not asked in this survey.				

Source: Extracted from the National Survey of Research and Experimental Development 2005/06 report (CeSTII 2007: 40).

Many questions arise from this trend data: *What is the nature of the firms that tend to collaborate with HEIs? Are these firms distinct from those who do not collaborate with HEIs? A small group collaborates with foreign HEIs, do these firms have distinct characteristics?* In order to gain a better picture of the firms that collaborate with HEIs, we first examine the full picture of those that collaborate generally. And although most (two-thirds) of the firms indicated that they collaborate with one or more partners, it is important to describe the third of the firms that do not collaborate.

Thus we first address the question, *What is the nature of firms that tend to collaborate?* And second, *Are these firms distinct from those who do not collaborate?* Profiles of firms in these two groups are presented, including general firm characteristics and indicators of R&D activity.

Table 2. Profiles of the total sample, and collaborative and non-collaborative firms

	Total sample (N=327)	Collaboration (N=218)*	No collaboration (N = 109)*
Firm charactersitics			
Firm size (no. of firms)			
Micro (1-9 employees)	39	16 (41%)	23 (59%)
Small (10-49 employees)	88	47 (53.4%)	41 (46.6%)
Medium (50-249 employees)	59	42 (71.2%)	17 (28.8%)
Large (250+ employees)	141	113 (80.1%)	28 (19.9%)
Sector (no. of firms)			
Agriculture	12	12 (100%)	-
Mining	14	14 (100%)	-
Manufacturing			
of which Low-technology	31	23 (74.2%)	8 (25.8%)
Medium-low technology	34	25 (73.5%)	9 (26.5%)
Medium-high technology	43	29 (67.4%)	14 (32.6%)
High-technology	36	33 (91.7%)	3 (8.3%)
Electricity, gas & water supply	4	4 (100%)	-
Construction	2	1 (50%)	1 (50%)
Wholesale & retail	4	2 (50%)	2 (50%)
Transport, storage & communication	9	5 (55.6%)	4 (44.4%)
Financial intermediation, real estate & business services	128	63 (49.2%)	65 (50.8%)
Community, social & personal services	10	7 (70%)	3 (30%)
R&D activity			
R&D expenditure (in Rands):			
Mean total R&D expenditure	18,374,165.14	25,530,105.5	4,062,284.4
Median total R&D expenditure	3,190,000.0	6,384,500.0	1,474,000.0
By type of research (mean %):			
Basic research	15.1	13.7	20.4
Applied research	38.9	39.4	37.4
Experimental research	67.3	61.8	78.2
Mean R&D personnel (headcount)	32.9	42.9	13.0
Mean FTE	25.7	34.4	8.4
R&D personnel intensity (mean of total R&D employees/total employees)	0.0	5.5	0.0

*Percentage of sample total in brackets.

Data source: R&D Survey 2005/06 dataset, CeSTII.

Firm characteristics

It can be seen in Table 2 above that the majority of the firms that collaborate with one or more collaborative partners are large firms and a significantly larger proportion of the large- and medium-sized firms tend to collaborate with universities, in comparison with the micro and small firms. More than half of the micro firms do not collaborate.

R&D activity

Interestingly, the firms that do not collaborate accounted for a mere seven percent of the total R&D expenditure. Furthermore, the collaborative firms' median R&D expenditure was more than four times higher than that the firms that do not collaborate, indicating that most of the 'big spenders' collaborate on their R&D activities. This is expected considering that the majority of the collaborative firms are the larger firms.

The collaborators also have a significantly higher R&D personnel intensity, with a mean number of R&D personnel more than three times higher than that of the non-collaborators.

The importance of the three types of research activities (basic, applied and experimental) for the collaborators and no-collaborators follow a similar trend with greater emphasis being placed on experimental research by all. The non-collaborators placed greater importance on basic science than the collaborators, which is interesting as it is expected that firms would seek to collaborate with other knowledge producers in the national innovation system, such as HEIs and science councils, for the more basic and applied research activities. This finding may be related to issues around Intellectual Property Rights.

The emphasis on applied and experimental research is in-line with the high proportion of collaborative firms in manufacturing, high and medium technology firms in particular. Interestingly, all of the agricultural and mining firms, which are likely to be large competitive firms, collaborate on their R&D activities. This may be indicative of the legacy systems of R&D support in South Africa, particularly the ARC and Mintech. Considering that the total sample is dominated by firms in the manufacturing and financial and business services sectors, we compared the characteristics of collaborating firms in these sectors in greater detail.

Firms in manufacturing and financial and business services

Both sectors are dominated by large firms (see Table 3). The manufacturing firms tend to be larger firms and the financial and business services sector has a larger proportion of small firms, which is characteristic of these sectors in South Africa (OECD 2007).

The financial and business services sector also tends to have a higher level of R&D activity. Although the manufacturing firms had a higher R&D expenditure, the financial and business services sector included 'bigger spenders' as indicated by the larger median R&D expenditure. The firms in the financial and business services sector also tended to have slightly more dedicated R&D personnel. The sector also showed a slightly greater emphasis on basic and applied research, but considerably fewer firms tended to collaborate with HEIs. This is in contrast to the manufacturing firms that account for more than half of the number of firms in the total sample that collaborate with HEIs. A relatively large number of firms in both sectors reported collaboration with firms (including own/affiliated and other firms) in South Africa and internationally.

Table 3. Profiles of the collaborative firms in manufacturing and financial and business services

	Manufacturing (N=110)		Financial and Business Services (N=63)	
Firm characteristics				
Firm size (no. of firms)				
Micro (1-9 employees)	9		4	
Small (10-49 employees)	20		23	
Medium (50-249 employees)	24		9	
Large (250+ employees)	57		27	
R&D activity				
R&D expenditure (in Rands):				
Mean total R&D expenditure	19,200,081.8		16,337,365.1	
Median total R&D expenditure	5,142,000.0		7,071,000.0	
By type of research (mean %):				
Basic research	13.6		18.9	
Applied research	38.2		39.0	
Experimental research	64.9		58.2	
Mean R&D personnel (headcount)	30.0		40.3	
Mean FTE	25.9		28.9	
Collaboration (no. of responses)				
	SA	Foreign	SA	Foreign
Higher education institutions (universities and technikons)	66	11	27	9
Science councils (e.g. CSIR, MRC)	38	7	20	3
Government research institutions	21	7	11	3
Members of own company/affiliated companies	43	27	26	16
Other companies (including specialist consultants)	44	24	30	18
Not-for-profit organisations	7	1	4	2

Data source: R&D Survey 2005/06 dataset, CeSTII.

This section indicated sectoral differences in the types of partners with which firms tend to collaborate. The importance placed on HEIs in particular differed by sector. The sectoral differences in the importance of HEIs as collaboration partners will be discussed below. *What is the nature of the firms that tend to collaborate with HEIs? Are these firms distinct from those who do not collaborate with HEIs?*

Collaboration propensities: collaboration with HEIs only versus collaboration with others

Firm characteristics

Although more than half of the collaborative firms reported collaboration with HEIs, this number includes firms that collaborate with other agencies as well. When the group of firms that collaborate with 'HEIs *only*' were singled out, it was found that 10% collaborated with 'HEIs *only*' (see Table 4 below). On the other hand, almost half (43.6%) of those that collaborate, did not collaborate with HEIs.

Interestingly, whereas micro firms account for a mere seven percent of the total number of collaborative firms, micro firms account for nearly a third of the firms that collaborate with 'HEIs only', which is equal to the number of large firms. Small firms account for the largest proportion of firms in the group, whereas the larger firms dominate the group whose collaboration partners *do not* include HEIs.

More than half of the firms that collaborate with 'HEIs only' were manufacturing firms and most of these were high-technology firms. Only one of the agricultural firms and none of the mining firms collaborate with 'HEIs only'. More than half of the medium-high technology manufacturing firms and the financial and business services firms that collaborate, partner with agencies other than HEIs.

R&D activity

The firms that collaborate with 'HEIs only' showed considerably lower levels of R&D activity with a mean R&D expenditure less than half that of the group that collaborate with agencies other than HEIs. The latter also includes more of the 'bigger spenders' as indicated by the median R&D expenditure, and accounted for 43.2% of the total for collaborative firms in comparison to the four percent that the former contributes. Firms that collaborate with agencies other than HEIs also had a larger number of R&D personnel. The low R&D activity of the firms collaborating with 'HEIs only' implies that these firms approach HEIs to substitute where they lack capacity and collaboration with HEIs may take the form of mutually beneficial R&D that is low cost.

Intriguingly, firms collaborating with 'HEIs only' placed greater importance on experimental research than those that collaborate with agencies other than HEIs. Basic research was also of little importance to the former. It could be inferred that they would rely on HEIs as an external source for basic research.

Collaboration

Most of the collaborative firms that do not collaborate with HEIs report collaboration with firms (within/affiliated firms and/or other firms). More than half of all collaborative firms that form collaborative partners lies within the firm or with an affiliated firm did not collaborate with HEIs. More than half of these 'within-firm' collaborations were with partners overseas implying that a large proportion of the collaborative firms that do not collaborate with HEIs may be large multinational firms. This raises the question, *If a large proportion of the collaborating firms that do not collaborate with HEIs tend to collaborate with foreign firms (within/affiliated and other firms), what is the nature of the firms that collaborate with foreign HEIs?*

Table 4. Profiles of firms that colloborate with HEIs *only* in comparison with those who collaborate with other institutions (excluding HEIs)

		Collaboration with HEIs only (N = 22)*		Collaboration excluding HEIs (N = 95)*	
Firm characteristics					
Firm size (no. of firms)					
Micro (1-9 employees)		5 (31.3%)		6 (37.5%)	
Small (10-49 employees)		8 (17%)		18 (38.3%)	
Medium (50-249 employees)		4 (9.5%)		21 (50%)	
Large (250+ employees)		5 (4.4%)		50 (44.2%)	
Sector (no. of firms)					
Agriculture		1 (8.3%)		4 (33.3%)	
Mining		-		4 (28.57%)	
Manufacturing					
of which	Low-technology	1 (4.3%)		8 (34.8%)	
	Medium-low technology	2 (8%)		7 (28%)	
	Medium-high technology	2 (6.9%)		15 (51.7%)	
	High-technology	7 (21.2%)		12 (36.4%)	
Electricity, gas & water supply		-		2 (50%)	
Construction		-		1 (100%)	
Wholesale & retail		-		2 (100%)	
Transport, storage & communication		2 (40%)		3 (60%)	
Financial intermediation, real estate & business services		6 (9.5%)		35 (55.6%)	
Community, social & personal services		1 (14.3%)		1 (14.3%)	
R&D activity					
R&D expenditure (in Rands):					
	Mean total R&D expenditure	10,366,454.55		25,322,663.2	
	Median total R&D expenditure	4,195,000.0		6,583,000.0	
By type of research (mean %):					
	Basic research	5.8		10.4	
	Applied research	34.3		40.4	
	Experimental research	75.6		66.8	
Mean R&D personnel (headcount)		26.0		35.1	
Mean FTE		19.8		29.3	
Collaboration (no. of responses)					
		SA	Foreign	SA	Foreign
Higher education instititions (universities and technikons)		22 (18.3%)	1 (3.2%)	N/A	N/A
Science councils (e.g. CSIR, MRC)		N/A	N/A	19 (23.17%)	3 (18.8%)
Government research institutions		N/A	N/A	12 (27.9%)	2 (14.3%)
Members of own company/affiliated companies		N/A	N/A	45 (54.2%)	31 (57.4%)
Other companies (including specialist consultants)		N/A	N/A	44 (44.4%)	24 (38.7%)
Not-for-profit organisations		N/A	N/A	4 (26.7%)	0

*Percentage of total collaborative sample in brackets.

Data source: R&D Survey 2005/06 dataset, CeSTII.
Collaboration with foreign HEIs

A relatively small number (31) of firms reported collaboration with HEIs situated outside of South Africa (see Table 5 below). These include firms that collaborate with South African HEIs as well. Only three firms reported collaboration with foreign HEIs only.

It can be seen in Table 5, that the firms that collaborate with foreign HEIs showed a propensity to collaborate with foreign agencies generally as this group accounted for more than half of the firms that report collaboration with all foreign agencies except within/affiliated firm partners. As was established previously, most of the firms that collaborate with partners within their firm or in affiliated firms overseas, do not report collaboration with HEIs. An interesting finding is that the firms that collaborate with foreign HEIs account for most of the firms that report collaboration with not-for-profit organisations in the overall collaborative sample. This finding may reflect the firms' social responsibility activities.

Table 5. Profile of firms that colloborate with HEIs outside of South Africa

	Collaboration with HEIs (N = 123)	Collaboration with foreign HEIs (N=31)
Firm characteristics		
Firm size (no. of firms)		
Micro (1-9 employees)	10	2 (20%)
Small (10-49 employees)	29	7 (24.1%)
Medium (50-249 employees)	21	4 (19%)
Large (250+ employees)	63	18 (28.6%)
Sector (no. of firms)		
Agriculture	8	5
Mining	10	6
Manufacturing		
of which Low-technology	15	2
Medium-low technology	18	2
Medium-high technology	13	1
High-technology	21	6
Electricity, gas & water supply	2	-
Construction	-	-
Wholesale & retail	-	-
Transport, storage & communication	2	-
Financial intermediation, real estate & business services	28	9
Community, social & personal services	6	-
R&D activity		
R&D expenditure (in Rands):		
Mean total R&D expenditure	25,690,325.2	38,194,580.65
Median total R&D expenditure	6,144,000.0	14,200,000.0
By type of research (mean %):		
Basic research	15.6	17.6
Applied research	38.6	39.4
Experimental research	58.0	46.5
Mean R&D personnel (headcount)	48.9	80.3
Mean FTE	38.3	64.0

Collaboration (no. of responses)				
	SA	Foreign	SA	Foreign
Higher education instititions (universities and technikons)	120	31	28 (23.3%)	31 (100%)
Science councils (e.g. CSIR, MRC)	63	13	19 (30.2%)	10 (76.9%)
Government research institutions	31	12	13 (41.9%)	8 (66.6%)
Members of own company/affiliated companies	38	23	15 (39.5%)	9 (39.1%)
Other companies (including specialist consultants)	55	38	21 (38.2%)	21 (55.3%)
Not-for-profit organisations	11	4	8 (72.7%)	3 (75%)

*Percentage of sample that collaborates with HEIs in brackets.

Data source: R&D Survey 2005/06 dataset, CeSTII.

The 31 firms that collaborate with foreign HEIs represented 14.2% of the collaborating sample and 21.3% of the total R&D expenditure. The mean R&D expenditure was larger than the total collaborating with HEIs and the median R&D expenditure was more than double. The level of R&D personnel intensity was considerably higher for this group of firms with the mean R&D personnel nearly double that of the total number of firms that collaborate with HEIs. These firms also showed a slightly larger percentage of basic research and a lower percentage of experimental research activity in comparison to the total collaborating with HEIs. The high level of the firms' R&D activity and collaboration activity generally implies that the firms' are more likely to engage international HEIs once a certain level of R&D expenditure is reached and also when collaboration frequency with other partners is already high.

6. Conclusion and recommendations for future research

The small emerging body of literature on UILs in South Africa indicates that UILs exist and are growing in importance in the university and industrial sectors. The limitation of the existing large-scale and in-depth research on UILs in South Africa is that this research tended to focus more on UILs from the perspective of the university. Research on UILs explaining the other side of the coin, that is, from the perspective of the firm is thus a gap that the paper begins to address.

This paper presents a first scan of the available national data on UILs from the perspective of the firm. Although it draws on data that is limited to a relatively small sample of R&D-performing firms, it provides insight into national trends of firms' pursuit of collaborative linkages with universities.

In South Africa only a small percentage (about 9%) of firms, which account for about 15% of innovative firms, tend to 'co-operate' with higher education institutions on innovative activities. And only about five percent refer to higher education institutions as important sources of information for their innovative activities. Although South Africa showed similar collaboration trends to that of the EU-27, the South African firms place greater importance on higher education as co-operation partners and less importance on

publicly accessible information sources. Both South Africa and the EU-27 raise questions about the low levels of UILs formed by innovating firms. This suggests relatively low interactivity between these two agencies in the national system of innovation, and raises concerns with regard to research utilisation and the harnessing of the university's potential as a significant contributor to economic growth and development.

Analyses of innovative South African firms' propensity to collaborate left many questions with regard to the nature of UILs in South Africa unanswered. One question refers to the importance of the university for more knowledge-intense activities. An analysis of R&D-performing firms' collaboration propensities was thus conducted. The R&D-performing firms can be thought of as an elevated sub-set of the innovative firms.

This analysis revealed interesting results. In particular, the analysis attempted to profile firms that collaborate with one or more of the agencies forming part of the national system of innovation in comparison with the profile of those that do not collaborate on their R&D activities. It was found that the firms that tend to collaborate were the larger firms with higher levels of R&D activity. The collaborating firms also tended to be 'big R&D spenders' and the group was dominated by firms in the manufacturing (mainly high and medium-high technology) and financial and business services sectors. Although the manufacturing sector included more large firms, the financial and business services sector had a higher level of R&D activity and included 'bigger R&D spenders' than the manufacturing sector. A larger proportion of firms in the manufacturing sector reported collaboration with higher education institutions in comparison to the financial and business services sector.

The firms that did not collaborate on their R&D activities included higher proportions of micro and small firms with considerably lower R&D activity. This group included a near-even number of firms in the financial and business services sector in comparison with those that collaborate. The firms that do not collaborate also tended to be less high-technology firms and did not include any of the agricultural or mining firms, which tend to be the larger competitive firms in South Africa.

Overall, HEIs were the most sought after partners for collaboration on R&D activities followed in prominence by other firms and partners within the firm or affiliated firms, with large proportions of collaboration with foreign firms. Science councils were also important collaboration partners. Considering the high average R&D activity of collaborating firms, it can be assumed that the firms tended to collaborate to complement their R&D capabilities rather than substitute their capabilities. Most of the firms sought to collaborate with local agencies.

When the firms that collaborated with 'HEIs only' were isolated, it was found that most of the firms also collaborated with one or more agencies in the national system of innovation. This indicated a degree of interactivity between these firms and others in the national system of innovation, which is desirable.

Only 22 firms collaborated with 'HEIs only', and this group is dominated by small and micro firms. A relatively small proportion of these firms' research activities were classified as basic research and a relatively large proportion was experimental research. These firms also have relatively low levels of R&D activity. These findings suggest that these firms sought to collaborate with HEIs as a substitute for their limited research capabilities and the collaboration with HEIs may take the form of mutually beneficial low-cost R&D activities.

On the hand, the firms that collaborate with agencies other than HEIs tended to be larger with greater R&D activity. These firms were dominated by firms in the financial and business services sector, and high- and medium-high technology manufacturing sector. These collaborating firms that did not collaborate with HEIs tended to prefer partners within/affiliated firms and/or other firms. More than half of the firms that collaborated with foreign firms did not collaborate with HEIs. The findings from this analysis suggest that a larger proportion of the multinational firms may not perceive HEIs to be important collaboration partners.

Furthermore, considerably fewer firms that collaborated with foreign HEIs reported collaboration with partners within/affiliated foreign firms. This sub-group of firms accounted for more than half of the collaborations with foreign partners in the total collaborative sample. These firms also tended to be 'very big R&D spenders' with very high levels of R&D activity, in comparison with the total number of firms that collaborate with HEIs.

Recommendations for future research

Two main findings are thus firstly, that intra- and inter-firm collaborations are more important for firms' innovative activities, but secondly, that HEIs are critical collaborative partners for R&D-performing firms. A third strong finding is that the group of collaborative firms was dominated by large firms, and a fourth relates to the sectoral profiles of those who collaborate in general, those who collaborate with HEIs and those who collaborate with foreign HEIs.

It is thus suggested that these trends can be used to interrogate the current policy emphasis on entrepreneurialism, incubation and creation of start-ups. How can these strategies be *complemented* with more targeted mechanisms to support interaction between higher education and large firms? (cf Gastrow 2008 who comes to a similar conclusion).

There is considerable scope to mine the R&D dataset further. For instance, an analysis that includes the primary research fields of firms' collaboration with universities may yield useful results for focusing universities' research activities. The analysis also raises questions for further research on UILs in South Africa. For instance, to investigate multinational firms' collaborative activities generally and with foreign HEIs specifically, or to investigate the collaborative practices of small firms, or to investigate the collaborative practices of the manufacturing sector as opposed to the services sector. More detailed insight is required into the nature of the different channels of interaction between universities and firms – do they relate to publicly available sources of

information, are they formal or informal, do they entail knowledge exchange or generation, and so on.

Finally, the insight into firms' pursuit of collaborative linkages provided in the paper may be useful to universities in considering where opportunities lie, in relation to their own capabilities, and new niche areas that may be pursued.

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